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MODESTUM

Structure and Content of e-Learning Information Environment Based on Geo-Information Technologies

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ABSTRACT

The urgency of the paper is determined by the continuous information development of all spheres of education: integration of new knowledge, accessibility of information technologies and computer facility aids, professionalization and computerization of educational activities. The purpose of the research is to develop the structure and content of learning information environment in a higher education institute on the basis of geo-information technologies. The authors show the possibilities of using geo-information technologies in teaching outside the scope of their typical application (geographic, geodetic, geological education). The principles of designing the information environment for training on the basis of geo-information technologies are developed, which is built into the general information environment of higher education institute. The peculiarities of using geo-information technologies in non-core training are revealed, and the structure of learning environment modules based on geo-information technologies is developed and their content is described. The authors adapted the system of criteria evaluating the the effectiveness of training information environment, carried out an empirical study of the quality of education information environment in a higher education institute on the basis of geo-information technologies. The paper is intended for teachers, specialists in the field of information as means of education.

Keywords: education, information environment, e-learning information environment, geo-information technologies, efficiency diagnostics, efficiency criteria of e-learning information environment

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State of the literature

- The use of geo-information technologies creates opportunities for research and organization of various information spaces, which makes it possible to consider them a sufficiently universal tool for teaching and transferring knowledge.
- The introduction of geo-information technologies into the information environment of training specialists of different profiles (in addition to the traditional areas of training) has not been sufficiently studied.
- Improvement of vocational training should ensure the development of information, educational and vocationally-oriented activities of students on the basis of modern information technology capabilities.

Contribution of this paper to the literature

- Modular structure of a training information environment based on geo-information technologies is proposed.
- Training assignment examples on the basis of geo-information technologies for specialists in various areas of training has been developed.
- Criteria for assessing the effectiveness of the training information environment are developed.

INTRODUCTION

The Urgency of the Problem

Modern higher education cannot be imagined without realization and implementation of information technologies for teaching, managing and documenting the educational process. The diversity and multidimensionality of existing information technologies, as well as traditions, level of development and material provision generate different ideas in the formation of an information environment for a higher education institute. The information environment, in the most general case, is part of a virtual space where subjects and objects of information processes interact and self-organize (Kolin, 2009; Deng et al., 2014; Kalyuzhny, 2015). The information environment includes a lot of information objects and connections between them; means and technologies for collecting, storing, transmitting (broadcasting), processing, producing and disseminating information, knowledge, a means of reproducing audiovisual information; organizational and legal structures supporting information processes.

Almost every higher education institute has its own information environment, its own system of representation, storage, processing and protection of information. Rationing of the information environment for a higher education institute is carried out only with respect to compliance with information security rules, protection of personal data, information systems and other legislative requirements.

Also, there are quite a lot of ideas about the educational function of an information environment for a higher education institute (information environment of training) - from the storage of educational and subject information and its provision by user requests to the maximum use of information and communication in education, essentially replacing the educational process itself (virtual educational environment, distance education, and so on.) (Zakharova, 2010; Arntzen & Krug, 2011; Prestridge, 2012). As a rule, the information environment for a higher education institute contains the following components: documentary, financial-accounting, personnel, educational, which are related to each other by main processes of educational activity (teaching, personnel training, pre-university training, research activity, management, quality management, marketing, educational and methodical provision) (Plomp et al., 2009; Levina, 2012; Levina et al., 2015).

The basis of our research is the presentation of an educational information environment as a dynamic system that provides the conditions for information, education and vocationally-oriented activity of subjects of education on the basis of modern possibilities of information technologies and computer facilities (Voogt, 2015; Kirilova, Volik & Vlasova, 2011). The multiplicity of information technologies makes it possible to expand the

possibilities of an information environment for a higher education institute in terms of education. Within the framework of training curricula for bachelors of specialties, we are proposing to implement geo-information technologies in the learning process for solving problems of economic, political and environmental development and managing natural, industrial and labor potential on the basis of geospatial information. Spatial analysis of any territories creates the opportunity for research and organization of various information spaces, which makes it possible to consider geo-information technologies as a sufficiently universal tool for teaching and transferring knowledge. Therefore, there is reason to believe that the use of geo-information technologies in education remains a promising one in a wide range of different educational disciplines beyond the typical areas of study (geography, biology, geodesy, geology, etc.).

We assume that the inclusion of geo-information technologies (through the development of organizational, methodical and mathematical provision) in the information environment of training will increase the efficiency and accessibility of the educational process of bachelors training in various fields.

The Goals and Objectives of the Study

We define as *the purpose of our research* to develop the structure and content of a training information environment on the basis of geo-information technologies' introduction in the educational process. The goal requires solving the following *tasks:*

- to develop the principles for organization of a training information environment on the basis of geo-information technologies;
- to develop a modular structure of a training information environment on the basis of geo-information technologies;
- to fill the module contents of a training information environment on the basis of geo-information technologies;
- to develop study assignments to teach students of various directions on the basis of geo-information technologies;
- to develop criteria and test the effectiveness of the training information environment on the basis of geo-information technologies.

MATERIALS AND METHODS

Experimental Research Base

The experimental base of the research is the Kazan (Privolzhsky) Federal University (Higher education institute 1), the Kazan National Research Technical University named after A. N. Tupolev (Higher education institute 2).

The study involved 349 people (students in various areas of vocational training and teachers).

Organizational Principles of the Training Information Environment on the Basis of Geo-Information Technologies

A modern understanding of the information approach (Robert, 2012; Kirilova & Vlasova, 2013; Levina et al., 2016) suggests that the aggregate of all types of information within the educational space (organizational, managerial, educational) and certain ways of its processing will be able to meet the current needs of management practice of educational systems such as: research methods, simulation, forecasting, improvement of all types of management. Continuous cyclic transformation of information into knowledge, with which one can "get" new information, serves as the basis for information analysis for all processes of educational activity. In the most general case, the structure of an information environment for a university consists of: information processes; regulatory

documents; information technology; interface; network infrastructure; methodical and educational information; and diagnostic materials (Kirilova, 2011; Volik, 2011; Mukhametzyanov, 2010; Vlasova, 2010).

The generalized principles of a training information environment include (Webster, 2004; Shreider, 2008; Maksimov, 2009; Krevsky et al., 2014):

- Multidimensionality (software, educational methodologies, diagnostic provision, databases of assignments, tasks, personal area of trainees, teachers, heads of departments and structures of the higher education institute);
- Integration (application of the spectrum of information technology capabilities for management and training);
- Multidisciplinary nature (availability of a database and knowledge base of educational disciplines, interdisciplinary communications in order to improve teaching methods);
- Adaptability (the ability to apply to various areas of training, the possibility of adjusting in the case of structural and content changes in management and training, taking into account psychological factors in the formation of educational and methodical provision, etc.);
- Cognitive nature (the priority of research, creative, analytical and predictive component of the student's educational and vocational activities);
- Variability (the possibility of individualization, differentiation and regionalization of training).

These principles allow us to present the training information environment as a subsystem of the information environment for a higher education institute, aimed at the development of students using the full range of information technologies.

For the purposes of pedagogical development, we use the potential of geo-information technologies and their inclusion in the information environment as a factor in improving the forms and methods of instruction that outstrips the educational content development in order to meet the needs of the labor market (Tsvetkov & Kulagin, 2003; Galton, 2009; Mayorov, 2012).

Features of geo-information technologies are:

1) Availability of interdisciplinary connections, which determine both the complexity of understanding and the multidimensionality of use;
2) Engineering and technical direction, which determines the scope of possible applications in education;
3) High information saturation of the work results;
4) The need to train the teaching staff in the field of application;

Geo-information technologies, integrating database with technologies, mathematical analysis procedures, visual and interactive simulation and image-mapping methods, enable the unification of spatially-distributed information necessary to ensure socio-economic development, planning and management of territories, the solution of various regional problems.

Structure of the Training Information Environment Using Geo-Information Technologies

The structure of the training information environment developed by the authors using geo-information technologies includes:

<table>
<tr><td colspan="3">TRAINING INFORMATION ENVIRONMENT</td><td>Personal Area
identification</td></tr>
<tr><td>Website of the higher education institute</td><td>subject:
Information systems in economics</td><td>theme:
Geographic information systems</td><td>Subject</td></tr>
<tr><td>e-learning resources</td><td colspan="2" rowspan="5">  </td><td>theme</td></tr>
<tr><td>Educational-methodical complexes</td><td>Lecture</td></tr>
<tr><td>Regulations</td><td>Training assignments</td></tr>
<tr><td>Directories</td><td>Control</td></tr>
<tr><td>Research work of students</td><td>Current academic performance</td></tr>
<tr><td colspan="4">Forum</td></tr>
</table>

Figure 1. The user interface of the training information environment

1) *Data warehouse*: a database of spatial information (cartographic, facto-graphic information, aerial photographs, satellite imagery, ground observation materials, etc.); a database of subject-oriented educational resources; a database of subject tasks and answers to them; a database of teachers; a database of students.

2) *Organizational-methodical module:* a set of educational standards, curricula, programs of disciplines, requirements to the level of knowledge; diagnostic materials (tests, tasks); results of student achievements.

3) *Reference module:* links to information resources and libraries; standards, terms and definitions for disciplines and areas of training; dictionaries; translators; a reference book on geo-information technologies and software products.

4) *Functional module:* communication between students and educational information, search, provision, feedback, formation of training applications, access management to subjects, topics, control, results.

5) *Geo-information module:* applications, technologies, manipulation with layers and objects, spatial simulation.

6) *Analytical module:* algorithms for analytical processing, statistical analysis, pattern recognition.

The user interface of the training information environment is shown in **Figure 1**.

The use of geo-information technologies in various sectors (geodesy, geology, geography, biology, construction, ecology, engineering systems, economic systems, etc.) creates new opportunities for information communications. This gives grounds to consider them a sufficiently universal tool for teaching and transferring knowledge in a wide range of different educational disciplines and areas of study.

The initial acquaintance with geo-information systems (GIS) is recommended within the framework of the "computer science" discipline, where the theory and practice of geo-information systems, methods and technologies for creating spatial data is studied. Furthermore, in the framework of specialist training in the areas

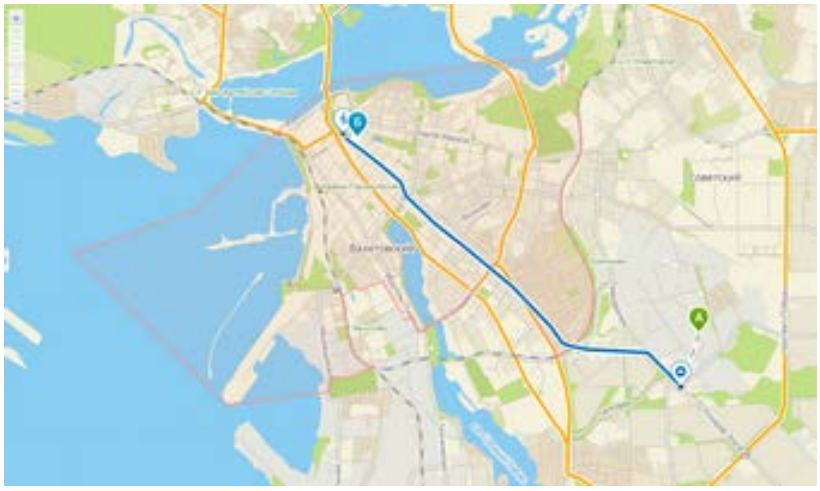

Figure 2. Map of the city district (Task 1)

Figure 3. Map of the city district (Task 2)

of safety of the techno-sphere, information systems and environments, applied computer science, telecommunication systems, management, within the discipline "information technologies", subject areas "GIS in nature management", "GIS in municipal management" and others were introduced.

Assignment Examples in the Training Information Environment Using Geo-Information Technologies

The set of tasks for the specified courses is selected taking into account the level of complexity and direction of specialist training. There are examples of tasks using geo-information technologies.

Task 1 "Ecological situation of the city" (specialty "Safety of the technosphere")

Based on the analysis of district road congestions, the location of industrial enterprises, the task is to build a thematic map, determine the level of contamination of the region (**Figure 2**).

Task 2 "Build a shop" (specialty "Management")

To develop a business plan for a home appliance store, the task is to find out the marketing need of the population of the city area represented on the map (**Figure 3**).

Figure 4. Map of the city district (Task 3)

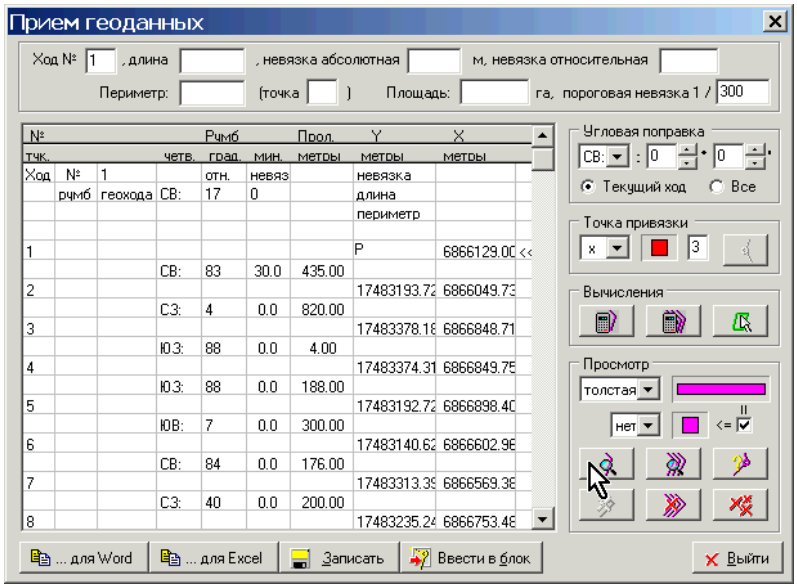

Figure 5. Geospatial data of the object (Task 4)

Task 3 "Build a network" (specialty "Telecommunication systems")

The task is to determine the optimal route for laying the cable, taking into account the location of streets, highways and railways, various underground utilities, as well as data on land owners, etc. (**Figure 4**).

Task 4 "Optimization of the GIS project database" (specialty "Information systems and environments")

The task is to analyze the existing geospatial data of an object, and add the required attributes to the database (**Figure 5**).

The set of presented types of tasks using geo-information technologies deals with spatial information and possesses certain specificity in organization and data processing. All the tasks within each area of specialist training are focused on future vocational activities.

RESULTS

The authors define the functions of the teacher within the training information environment:

1) *Didactic*: The organization of the learning process through the information environment, including the selection of teaching technologies;

2) *Projective:* The design of training discipline within the educational standard, curriculum and work program;

3) *Methodical*: The development of a system of tasks for mastering the academic discipline.

We propose a general scheme for constructing study assignments using geo-information technologies:

- 0 type: definition of object type on spatial data;
- 1st type: where one can place an object with certain operating conditions;
- 2nd type: what trends (temporal changes) can an object located in a certain space have;
- 3rd type: what happens if one adds an object to the existing spatial structure;
- 4th type: analysis and improvement of existing GIS;

4) *Orientation*: Helping students to master the material, forming a readiness for independent learning activities;

5) *Control*: Providing a differentiated system for evaluating learning outcomes.

Within the framework of the proposed information environment, the student supervises the progress of the tasks. The environment provides the learner with learning manuals, recommendations, assesses and analyzes the results, checks controlling tasks. The criterion for quality of mastering the educational material is reduced to the quality of solving the problem of the subject domain, based on the correctness and speed of the tasks' performance;

6) *Socializing*: Allows strengthening the student's starting opportunities in the labor market, developing capabilities and abilities for future vocational activities.

To analyze the training information environment on the basis of geo-information technologies, the criteria for assessing the information environment have been supplemented by the authors (Nikitina, 2015; Tarasov, 2011; Kudryashova & Etingof, 2013, etc.). Based on the selection of experts, the following criteria are selected:

- Informative nature- availability of necessary and sufficient educational, auxiliary and organizational material;
- Systemic nature- the availability of interconnected contextual, methodical and organizational components of training;
- Manageability- the ability to achieve learning objectives through an information environment;
- Diagnostic nature- the ability to determine the level of mastering the educational material at any stage of training;
- Effectiveness- achievement of planned learning outcomes and the possibility of their improvement;
- Accessibility- the ability to work with information according to the available access rights;
- Communicative nature- convenience of interaction of users with the interface of the environment;

Table 1. Analysis of the effectiveness of learning information environment on the basis of geo-information technologies, average scores

List of criteria	Higher education institute 1		Higher education institute 2	
	Students	Teachers	Students	Teachers
Informative nature C1	4,86	4,53	4,9	4,63
Systemic nature C2	4,92	4,8	4,83	4,76
Manageability K3	4,2	4,36	4,31	4,4
Diagnostic nature C 4	5	5	5	5
Effectiveness C 5	4,3	4,8	4,17	4,76
Availability C 6	4,8	5	4,84	5
Communicative nature C 7	4,46	4,37	4,39	4,51
Motivational nature C 8	4,57	4,71	4,55	4,62

Table 2. Statistical analysis of the consistency of opinions on the effectiveness of the training information environment on the basis of geo-information technologies

STUDENTS	Performance criteria							
	C1	C2	C3	C4	C5	C6	C7	C8
	TEACHERS							
	0,58	0,62	0,56	1	0,47	0,66	0,54	0,43

- Motivational nature- the presence of interest in the work, the motivation for creativity, the independent mastering of the material outside the educational activity with the help of the environment.

In order to identify the effectiveness of the educational information environment developed by the authors on the basis of geo-information technologies, a survey was conducted of students (14 study groups, total 327 people), mastering the academic disciplines and subject teachers who accompany the training (22 people in all) working with the training environment. Each criterion was evaluated on a 5-point scale. The results of the evaluation are shown in **Table 1**.

In order to determine the consistency of the teachers' and students' views on the effectiveness of the training information environment on the basis of geo-information technologies, the Kendell concordance coefficient was calculated. The results are given in **Table 2**.

The received results testify to sufficient coordination of opinions of teachers and students on the effectiveness of the training information environment on the basis of geo-information technologies (mean value of the concordance coefficient w = 0.6).

The analysis of the evaluation of each criterion separately allowed to identify the problem areas and suggest possible ways of improving the information environment, in particular, to increase the information content of the system by adding normative information in the area of training; to strengthen the effectiveness of the system as a factor in improving training activities by highlighting the rating of each student; to improve the convenience of the interface on user requests and so on.

The analysis of the motivational criterion of the training information environment on the basis of geo-information technologies is of special interest. Working with the information environment always attracts students' interest; they are easily adapted, intuitively tuned to work in comparison with traditional education, where the teacher acts as the main carrier of educational information. As the learning tasks become more complex, the effectiveness of training starts to depend on the student's ability and readiness for activity, his independence and criticality. From the initial knowledge base, the motivation of many students to work with the information environment begins to decrease. In the future, there is either an adaptation to the information environment, or its rejection, which affects the level of effectiveness and motivation.

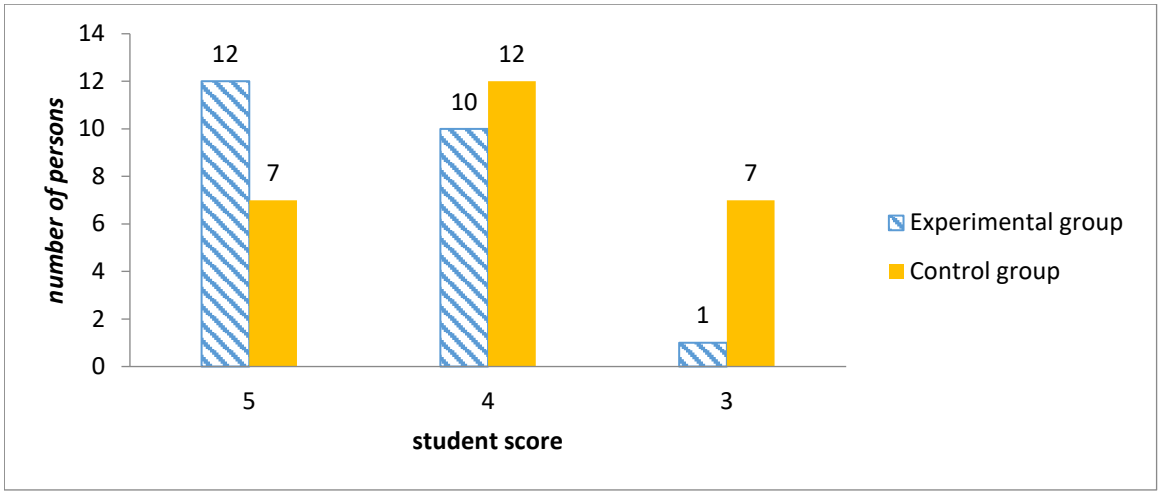

Figure 6. Effectiveness of the project "Environmental safety of the city" for students of experimental and control groups

As part of the pedagogical experiment, we also evaluated the results of students' project course for the direction of training "Security of Techno-sphere" in the higher education institute on the "Environmental Safety" discipline. The project task was performed by the students themselves. In the analysis, the group of students in the third year of their bachelor's degree took part: the experimental group (23 people), who mastered the academic disciplines with the use of the training information environment on the basis of geo-information technologies, and the control group (24 people), working on the basis of traditional educational technologies (including, information and active technologies). It is a remarkable fact that all students of the experimental group built their project on the basis of geo-information technology (analysis, construction and research of data), in the control group, only 3 people (12.5%) took advantage of the geo-information technologies.

The results of the project on environmental safety (5 points scale) are shown in **Figure 6**.

In addition to the pronounced level of effectiveness of the experimental groups (on average, 23% higher than the control group), the teachers included in the commission for the controlling of the project noted that the students of the experimental group had better mastery of vocational terminology, systematic understanding of the subject area, and the presence of explicit vocational orientation. So, when using the training information environment on the basis of geo-information technologies, students' motivation for learning and its effectiveness increase, the role of the teacher is transformed, the vocational competencies of students are improved. The expansion of the traditional sphere of geo-information technologies' application in education makes it possible to increase the effectiveness of teaching - to introduce new content and new means in them, to enable the world to be represented in all its diversity, to trace its structural and functional organization.

DISCUSSION

The authors have scientifically substantiated and experimentally tested the training information environment on the basis of geo-information technologies.

In modern conditions of excessive scientific and educational information provided to students, the use of all types of information technology in the educational process significantly changes the functions of the student and teacher. There is a growing demand both for the training of the teacher and his or her skills, and for the means of instruction (Gorski, 2005; Kozma & Vota, 2014; Kirilova, 2011; Robert, 2012). The introduction of geo-information technologies into the educational process, in addition to the advantages identified by the authors (visualization of data, their spatial representation, the development of creative thinking of students, their professionalization, etc.)

can cause some difficulties associated with the organization of educational activities (Bell & Newton, 2013; Ostroumova, 2011; Pranov & Rassokhina, 2011).

First, there is an increase in the requirements for the information competence of teachers, their system of knowledge, skills, and methods of activity in the field of spatial simulation and design using geo-information technologies. Geo-information technologies require additional training of teachers, development of hardware and software.

Secondly, teachers must fully possess the methodical competence that allow them to develop a system of practice-oriented tasks adequate to the requirements of educational standards on the basis of geo-information technologies.

Thirdly, teachers must have organizational and managerial competence, which allow them to accompany the educational process, create conditions for the individual development of students.

CONCLUSION

1) The use of geo-information technologies in the information environment of a higher education institute allows increasing the effectiveness of teaching, introducing new content and new means into the educational process, thereby ensuring its development.

2) The developed structure of the training information environment on the basis of geo-information technologies is quite universal and can be meaningfully adapted to any engineering specialty.

3) The technology for the development of study assignments based on geo-information technologies is implemented on specific examples and is used to train students of various fields, can be used in retraining of personnel and the system of professional development.

4) The developed educational and methodical provision of the training information environment on the basis of geo-information technologies is used for training bachelors in the field of ecology, nature management, management, and telecommunication and information systems.

5) The use of a set of objective tasks on the basis of geo-information technologies in the vocational training of bachelors causes the change and development of their vocational experience.

6) The criteria system for assessing the training information environment on the basis of geo-information technologies has shown its applicability in assessing the quality of information environments.

7) Modern methods of obtaining and processing information based on geo-information technologies will allow graduates of various engineering professions to improve their professional activities, thereby ensuring continuity of education and further development of industries.

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